REMARKS

In the Office Action of August 3, 2001, Claims 1, 2, 4 - 7, 9 and 10 were rejected. No claim was allowed. In response, Claims 1, 2, 6 and 7 are amended. A marked-up copy of the changes made is attached hereto. Reconsideration and reexamination are respectfully requested in view of the following remarks.

Rejection of Claims 1 - 10 under 35 U.S.C. §112, second paragraph

Claims 2 and 7 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite. The Examiner alleges that "temperature" does not have units of energy as eV. In response, the term "temperature" is changed to "energy" as suggested by the Examiner.

It is therefore respectfully submitted that the rejection is thereby overcome.

Rejection of Claims 1, 2, 4, 5, 6, 7, 9 and 10 under 35 U.S.C. §103 over Satou et al in view of H. Nishino et al

Claims 1, 2, 4, 5, 6, 7, 9 and 10 were rejected under 35 U.S.C. §103 as obvious over Satou et al (U.S. Patent No. 5,961,850) in view of H. Nishino et al. The Examiner takes the position that Satou et al teaches various limitations of the claimed invention, as listed in items i. through viii. on pages 3 - 4 of the Office Action. The Examiner acknowledges that Satou et al does not teach

(ix.) a gas that contains at least carbon and fluorine wherein a gas species is generated which contains carbon and fluorine according to a plasma dissociation, and (x.) plasma generation means which generates a plasma in which the degree of plasma dissociation is a "middle" degree and the gas species containing carbon and fluorine is generated fully in the plasma. The Examiner alleges that Nishino shows (xi.) a gas that contains at least carbon and fluorine wherein a gas species is generated which contains carbon and fluorine according to a plasma dissociation, and (xii.) a plasma processing apparatus comprising plasma generation means in which the degree of plasma dissociation is a "middle" degree and the gas species containing carbon and fluorine is generated fully in the plasma. The Examiner takes the position that it would be obvious to implement H. Nishino et al's fluoromethane as Satou et al's etchant gas. With respect to limitation that the claimed frequency be between 300 MHz and 1GHz, the Examiner takes the position that it would have been obvious to reduce the microwave frequency power application as taught by H. Nishino et al in order to impart the desired extent of dissociation.

This rejection is respectfully traversed as it may apply to the claims as amended herein. The present invention is directed to a plasma processing apparatus and method using a gas containing gas species that contain fluorine and carbon. Features that distinguish the present invention from the methods described in the cited

references include that the degree of plasma dissociation is a middle or intermediate degree (that is, a relatively high level of CF_2, and CF compared to the amount of F) and that a side wall of the vacuum processing chamber is controlled to have a range of 10 °C to 120 °C. As explained more fully in the specification, for example, on pages 2 - 3, a middle or intermediate degree of dissociation is desirable for etching silicon oxide. As explained more fully in the specification, for example on pages 9 - 11, the low temperature of 10 °C to 120 °C for a side wall of the vacuum processing chamber serves to limit the amount of gas discharge from reaction products that become deposited on the side wall. The range of 10 °C to 120 °C is selected as being significantly lower that the desorption temperature of the reaction products. The amount of gas discharge from the surface of the side wall remains limited and stable even when there are temperature fluctuations of ± 10 °C, thereby providing more stable deposition conditions.

As stated previously, these features are neither disclosed nor suggested by the cited references. In particular, Satou et al does not disclose processing with gas species containing carbon and fluorine. Rather, the process described in Satou et al involves the gases BCl_3 and Cl_2 and an aluminum wiring substrate, wherein one of the reaction products of the process is $AlCl_3$. There is no teaching or suggestion in Satou et al of controlling the extent of dissociation of a processing gas. With respect

to the temperature of the side wall, the reference teaches that the temperature of the side wall of the processing chamber should kept at a high temperature to prevent the deposition of reaction products on the side wall of the processing chamber. In the context of the process described in Satou et al, the recommended temperature for the side wall of the processing chamber is 100 °C to 400 °C, a temperature range that is selected because it is greater than the temperature (100 °C) at which $AlCl_3$ solidifies at 1 Torr. (On the other hand, in the apparatus and process of the present invention, the temperature range of the side wall of the present invention is maintained to be much lower than the desorption temperature, typically about 250 °C, of the reaction products of the particular process of the present invention.) Although Satou et al describes the cooling to -200 °C to 100 °C of surfaces such as the specimen mount, bottom portion of the chamber and exhaust pipe, these surfaces are located downstream from the processing chamber area. In the processing chamber itself, Satou et al clearly teaches away from cooling the side walls of the reaction chamber and instead teaches that these wall should be kept at an elevated temperature to avoid the deposition of reaction products thereon. Moreover, any incidental overlap between the ranges of side wall temperature of Satou et al (100 °C to 400 °C) and the present invention (10 °C to 120 °) would not suggest the limitation of the present invention in view of the

opposite purposes accomplished by the control of the side wall temperature.

Moreover, H. Nishino et al does not supply the elements missing from Satou et al. H. Nishino et al describes a etching treatment of silicon wherein a mixture of CF_4 and O_2 are discharged within a quartz tube by applying a 2.45 GHz microwave to generate "fluorine and oxygen atoms". There is nothing in H. Nishino et al to suggest a generation of "gas species containing carbon and fluorine" (that is, gas molecules containing both carbon and fluorine, such as CF, CF_2, etc.) with a middle degree of dissociation of the gas. Therefore, the Examiner's statements in xi. and xii. regarding what is disclosed in H. Nishino et al are in error.

The Examiner takes the position that it would be obvious, as a matter of optimization, to reduce the microwave frequency power application from 2.45 GHz to the range of 300 MHz to 1 GHz to impart the desired extent of dissociation. It is respectfully submitted that there is nothing in H. Nishino et al to suggest any desirability of achieving lesser degree of dissociation than the generation of "fluorine and oxygen atoms", particularly since H. Nishino et al does not relate to the etching of an insulating film, as required by the amended claims, wherein gas species such as CF and CF_2 are desirable. Therefore, there is no motivation in H. Nishino et al to reduce the microwave frequency power that is applied to the CF_4 and O_2 to achieve a reduced dissociation of CF_4.

Moreover, H. Nishino et al is silent on the subject of controlling a side wall temperature in a processing chamber.

Moreover, Claims 1 and 6 are amended herein to provide that the sample to be etched, which is recited in the apparatus Claim 1 as an element of the claimed apparatus, is an insulating film. This feature is neither disclosed nor suggested by Satou or Nishino. In the present invention, the selection of particular parameters of electron energy and side wall temperature is based on the etching characteristics of insulating films, which is neither taught nor suggested by Satou or Nishino

In view of the above, it is respectfully submitted that the combination of the cited references does not teach or suggest the claimed invention. Accordingly, Claims 1, 2, 4, 5, 6, 7, 9 and 10 would not have been obvious over Satou et al (U.S. Patent No. 5,961,850) in view of H. Nishino et al.

Conclusion

In view of the foregoing amendments and remarks, it is respectfully submitted that Claims 1, 2, 4, 5, 6, 7, 9 and 10 are in condition for allowance. Favorable reconsideration is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR § 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Deposit

Account No. 01-2135 (Case No. 503.37698X00) and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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1.(three times amended) In a plasma processing apparatus for etching an insulating film, the plasma processing apparatus having a vacuum processing chamber, a sample table for mounting a sample which is processed in said vacuum processing chamber, and a plasma generation means, wherein a plasma processing is carried out by generating a plasma in response to introduction of a gas which contains at least carbon and fluorine, and a gas species is generated which contains carbon and fluorine according to a plasma dissociation, the plasma processing apparatus comprising:

plasma generation means comprising an electron cyclotron resonance system in which a microwave is provided having a frequency of from 300 MHz to 1 GHz and which generates a plasma in which the degree of plasma dissociation is an intermediate degree and said gas species containing carbon and fluorine is generated fully in the plasma, and a temperature of a region which forms a side wall of said vacuum processing chamber is controlled to have a range of 10 °C to 120 °C and wherein the sample for etching by the plasma is an insulating film.

2. (twice amended) A plasma processing apparatus according to Claim 1, wherein

said plasma generation means is a source of plasma in which an electron ~~temperature~~ energy is in a range of from

0.25 eV to 1 eV.

6. (three times amended) In a plasma processing method using a vacuum processing chamber, a sample table for mounting a sample which is processed in said vacuum processing chamber wherein the sample is an insulating film, and a plasma generation means, wherein a plasma processing is carried out by generating a plasma in response to introduction of a gas which contains at least carbon and fluorine, and a gas species is generated which contains a carbon and fluorine according to a plasma dissociation, the plasma processing method comprising the steps of:

generating a plasma, wherein said plasma generation is effected using an electron cyclotron resonance system in which a microwave having a frequency of from 300 MHz to 1 GHz is employed and wherein a degree of plasma dissociation is an intermediate degree and said gas species containing carbon and fluorine is generated fully in the plasma, and controlling a temperature of a region which forms a side wall of said vacuum processing chamber to have a range of 10 °C to 120 °C.

7. (twice amended) A plasma processing method according to claim 6, wherein

said plasma generation produces a plasma in which an electron ~~temperature~~ energy is a range of from 0.25 eV to 1 eV.